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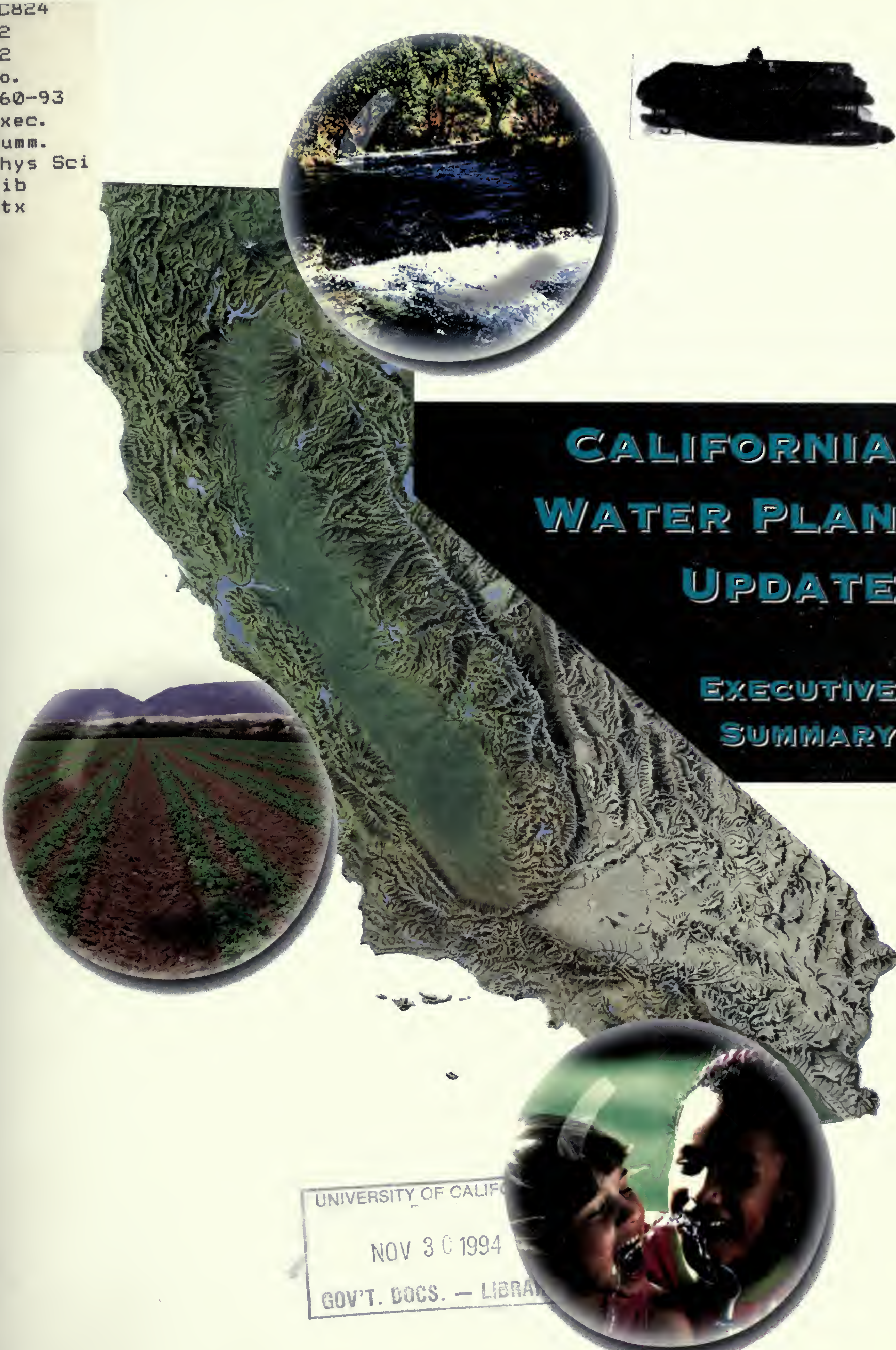

California Water Plan Update

Executive Summary

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Bulletin 160-93

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Foreword

Over 35 years have passed since the California Water Plan was published in 1957 to guide and coordinate beneficial use of California's water resources. In the ensuing years, our population has continued to grow, approaches to water resource management have changed, and water policies have become a complex mix of public input, legislation, litigation, and federal mandates. Bulletin 160–93, *The California Water Plan Update*, is a two–volume work that documents much of how population growth, land use, and water allocations for the environment are affecting water resource management. The bulletin discusses the effects of more stringent water quality standards, the Endangered Species acts, the Central Valley Project Improvement Act of 1992, and efforts to solve problems in the San Francisco Bay-Sacramento–San Joaquin River Delta estuary. Most importantly, Bulletin 160–93 presents both statewide and regional water budgets and reveals the gap between supply and demand that must be filled if California is to have reliable water supplies. It differs from the five previous water plan updates by:

- estimating environmental water needs separately and accounting for these needs along with urban and agricultural water demands;
- presenting water demand management methods, including conservation and land retirement, as additional means of meeting water needs; and,
- presenting two separate water balance scenarios for average and drought conditions.

The bulletin was developed with extensive public involvement. An outreach advisory committee made up of representatives of urban, agricultural, and environmental interests was established in July 1992 to assist the Department of Water Resources in developing the bulletin. The committee met regularly to review and comment on the content and adequacy of work in progress. In addition, the California Water Commission held public hearings in each of the ten major hydrologic regions to receive comments from the public about the November 1993 draft of *The California Water Plan Update*. Summaries of the comments received during the public hearing and comment period are in Appendix B of the bulletin.

This executive summary highlights the major points of Bulletin 160–93. Condensing over 700 pages of information into less than 50 requires that much of the background, figures, and data be generalized or excluded. Thus, this report is an overview of where California's water resource planning must focus to ensure reliable supplies. The data contained here and in Bulletin 160–93 are current as of 1993. However, a few events and agreements which occurred during the first part of 1994 are briefly discussed in the report. Readers should turn to Bulletin 160–93 to answer questions that the executive summary might raise.

David N. Kennedy
Director

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Chapter 1

Introduction

Several events with far–reaching consequences have altered water management in California since 1987, the last year an update to the California Water Plan was published. A drought that lasted six years strained the State's water supply system. During the last year of drought, 1992, actions to protect threatened aquatic species changed the operations of California's two largest water projects, the State Water Project and the Central Valley Project. That same year, the Central Valley Project Improvement Act passed, reallocating CVP supplies to protect natural resources. With severely limited supplies and fewer demands fully met, California realized that its water management system was no longer providing adequately reliable service, and the reliability of future supplies was highly uncertain.

In October 1991, amendments to California Water Code Sections 10004 and 10005 passed, requiring that the State's water plan be updated every five years. *The California Water Plan Update*, Bulletin 160–93, is the first update to be issued according to these amendments. This executive summary condenses the major findings and conclusions in Bulletin 160–93. After a short background discussion and an abstract of how recent acts and laws are affecting California's water resource management, essential supply and demand figures are presented. Next, options for balancing water supply and demand are outlined. Finally, major conclusions and recommendations from the bulletin are recapped. Key findings of Bulletin 160-93 are:

- During drought, present supplies are insufficient to meet present urban, agricultural, and environmental demands.
- By 2020, without improved water management and additional facilities, annual shortages of 3.7 to 5.7 maf could occur in average water years. Annual drought year shortages could increase to 7.0 to 9.0 maf.

Background

In most areas of California, the 1987–92 drought caused a marked increase in urban water conservation, reduced surface water supplies for agriculture, and stressed environmental resources. Some urban areas resorted to mandatory rationing, farmers in several agricultural areas chose to leave part of their acreage fallow, and ecosystems in certain regions endured harsh impacts. Still, innovative water banking, water transfers, and changes in project operations helped reduce the harmful effects of drought. The six–year drought and the need for a comprehensive policy to guide California's water management and planning prompted the Governor to announce his water policy on April 6, 1992. The policy provided general guidance in developing the options in Bulletin 160–93.

Recent Changes in the Institutional Framework

For decades, the San Francisco Bay-Sacramento–San Joaquin River Delta estuary has been the focal point for a wide variety of water–related issues, generating

The Governor's Water Policy

Here are key elements of the Governor's water policy as announced on April 6, 1992. As the Governor stressed, each of these elements must be linked in such a way that no single interest (urban, agricultural, or environmental) gains at the expense of another.

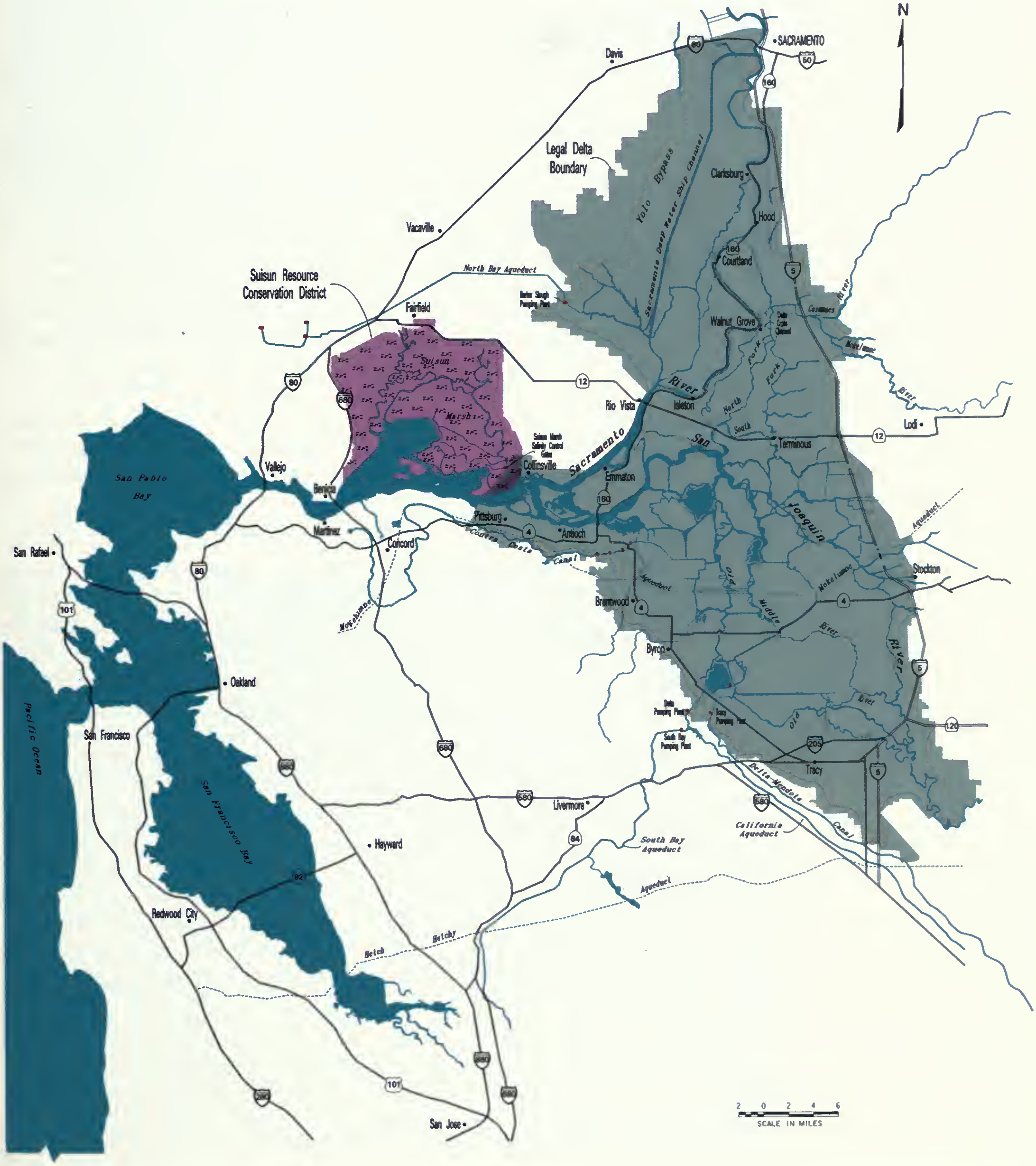
- Fixing the Delta
- Reduction of Ground Water Overdraft
- Water Marketing and Transfers
- Additional Water for Fish and Wildlife
- Additional Storage Facilities
- Water Conservation
- Water Recycling
- Desalination
- Transfer of the federal Central Valley Project to State Control
- Colorado River Water Banking

more investigations than any other waterway system in California. Major components of the complex Bay-Delta system include the Suisun Marsh, San Pablo Bay, and the Delta estuary. Two–thirds of the State's population and millions of acres of agricultural land receive part or all of their water supplies from the Bay-Delta. More than 100 species of fish use the Bay-Delta system. The Suisun Marsh covers 80,000 acres and is the largest contiguous wetland remaining in California. The entire system provides habitat for hundreds of species of fish, migratory waterfowl, mammals, and plants while also supporting extensive farming and recreational activities. The Delta and its tributaries, the Sacramento and San Joaquin rivers, are critical to California's water supply picture (see Figure ES-1). Water quality issues affecting these water bodies affect supplies from California's key water supply hub.

In February 1993, the National Marine Fisheries Service issued its biological opinion for the threatened winter–run chinook salmon (and later changed its designation to endangered). In March 1993, the U.S. Fish and Wildlife Service issued its biological opinion for the threatened Delta smelt. Both species had been listed under the federal and State Endangered Species acts because of population declines. The biological opinions impose restrictions on exports from the Bay–Delta. In addition, the CVPIA reallocates over 1 million acre–feet of CVP supplies to the protection of fish, wildlife, and their habitat. In 1993, about 400,000 acre–feet of reallocated CVP supplies benefited winter–run salmon and Delta smelt. The act's ultimate effect on Delta exports and how the environmental water will be used for the long–term are yet to be determined.

Other factors that will likely impose added restrictions on Delta exports are the State Water Resources Control Board's Bay–Delta proceedings and the U.S. Environmental Protection Agency's proposed Bay–Delta water quality standards. In response to the Governor's April 1992 water policy statement, SWRCB proceeded with a process to establish interim Bay–Delta standards (proposed Water Right Decision 1630) to provide immediate protection for fish and wildlife. In April 1993, the Governor asked SWRCB to withdraw its proposed Decision 1630 and instead focus efforts on establishing permanent standards since recent federal actions had effectively pre–empted State interim standards and provided interim protection for the Bay–Delta environment. By the end of 1993, EPA announced its proposed standards for the estuary in place of SWRCB water quality standards EPA had rejected in 1991.

Figure ES-1. The Sacramento-San Joaquin Delta and San Francisco Bay



In April 1994, the SWRCB began a series of workshops to review Delta protection standards adopted in its 1991 Water Quality Control Plan for Salinity and to examine proposed federal EPA standards issued in December 1993. This process is intended to help establish a draft SWRCB Delta regulatory plan acceptable to both the State and federal governments, to be released in December 1994. The plan will be developed in accordance with the Triennial Review requirements of the Clean Water Act.

More recently, the California Water Policy Council, created to coordinate activities related to the State's long-term water policy, and the Federal Ecosystem Directorate (sometimes referred to as "Club Fed"), comprising representatives from the EPA, NMFS, USFWS, and the USBR, have developed and signed a framework agreement for the Bay-Delta Estuary. The agreement provides for improved coordination and communication among State and federal agencies with resource management responsibilities in the estuary. It covers the water quality standards setting process; coordinates water supply project operations with requirements of water quality standards, endangered species laws, and the CVPIA; and provides for cooperation in planning and developing long-term solutions to the problems affecting the estuary's major public values. Coordination of State-federal resource management and long-range planning in the Bay-Delta estuary is necessary to promote regulatory consistency and stability, and to address the estuary's environmental problems, in a manner that minimizes economic and water costs to California.

Changing Conditions

Regulatory consistency and stability in the Bay-Delta estuary are also crucial to facilitating water transfers. Water transfers and marketing are integral components of California's water supply network. With appropriate safeguards against adverse environmental and third party effects, water transfers are an important tool for

Water Transfer Criteria

In his water policy statement of April 6, 1992, the Governor stated that the following five criteria must be met in developing a fair and effective water transfer policy.

- Water transfers must be voluntary, and they must result in transfers that are real, not paper water. Above all, water rights of sellers must not be impaired.
- Water transfers must not harm fish and wildlife resources or their habitats.
- There needs to be assurances that transfers will not cause overdraft or degradation of ground water basins.
- Entities receiving transferred water should be required to show that they are making efficient use of existing water supplies, including carrying out urban Best Management Practices or agricultural Efficient Water Management Practices.
- Water districts and agencies that hold water rights or contracts to transferred water should have a strong role in deciding how transfers are carried out. Impacts on the fiscal integrity of the districts and on the economies of small agricultural communities must be considered.

solving some of California's supply and allocation problems. There are generally fewer environmental impacts associated with transfers than with construction of conventional projects, and although often difficult to implement, transfers can be carried out more quickly and usually at less cost than construction of additional facilities.

During the 1987–92 drought, many water transfers took place between areas that could temporarily reduce usage and areas with water shortages. Some of these transfers were part of the State Drought Water Bank, which was designed to move water from areas of greatest availability to areas of greatest need. There were three sources of water for the 1991 State Drought Water Bank: temporary surplus in reservoirs, surface supplies freed up by the use of ground water, and surface supplies freed up by fallowing farm land. (The 1992 State Drought Water Bank did not purchase surface supplies freed up by fallowing.) Transfers of water outside the State–sponsored Drought Water Bank have also become more prevalent; many of these transfers involve the Department of Water Resources because they require conveyance of the transferred water through SWP facilities.

At the same time, California's water supply infrastructure is limited in its ability to transfer marketed water due to constraints placed on export pumping from the Delta (what some people refer to as "the institutional drought"). For example, in 1993, an above normal runoff year, environmental restrictions limited CVP deliveries to 50 percent of contracted supply for all federal water service contractors in the area from Tracy to Kettleman City. Such limitations will exacerbate ground water overdraft in the San Joaquin River and Tulare Lake regions (Figure ES-2) because surface supplies in wet years will not be available to recharge ground water that was used during dry years to replace the shortfall in surface supplies.

It may take a decade or more to fully assess the cumulative effects of the biological opinions, the CVPIA, more stringent water quality standards, and increased water transfers. In that time, the effects will be somewhat offset because adjustments to water demand patterns will probably lead to more efficient use of water, and options for improving the supply system's reliability and flexibility will probably be implemented. In the short–term, however, those areas of California relying on the Delta for all or part of their water face great uncertainty about supply reliability. Until solutions to complex Delta problems are identified and put in place, many Californians will experience more frequent and severe shortages. Without solutions to key Bay–Delta problems, many of the major proposed water supply programs north and south of the Delta are not feasible.

Figure ES-2. Hydrologic Regions of California

Chapter 2

Water Supplies

In analyses used to develop Bulletin 160–93, a *normalized* 1990 was used as the base year. (Normalization is the process of adjusting actual water use or supply in a given year to account for unusual events such as dry weather conditions, government interventions for agriculture, rationing programs, or other irregularities.) In 1990, California generally had adequately reliable supplies that met average annual urban, agricultural, and environmental water demands. However, the 1987–92 drought caused shortages in some California communities, such as Santa Barbara County, and impacted environmental resources, such as Central Valley wetland habitat.

Prior California Water Plan updates determined the existing base case for water supply and demand then balanced forecasted future demand against existing supply and against future supply and demand management options. To better illustrate overall supply availability, Bulletin 160–93 presents two water supply and demand scenarios, an average year and a drought year, for the 1990 level of development and for forecasts to 2020. What follows is an overview of California's surface and ground water supplies and of water quality problems that affect the availability of supply. At the close of each section are Bulletin 160–93 recommendations for improving water management planning and addressing water quality issues. Figure ES-3 shows the disposition of California's average annual total water supply.

Surface Water Supplies

The Sacramento and San Joaquin rivers have provided an average of nearly 15.5 million acre–feet annually for urban and agricultural uses. The supply for these uses

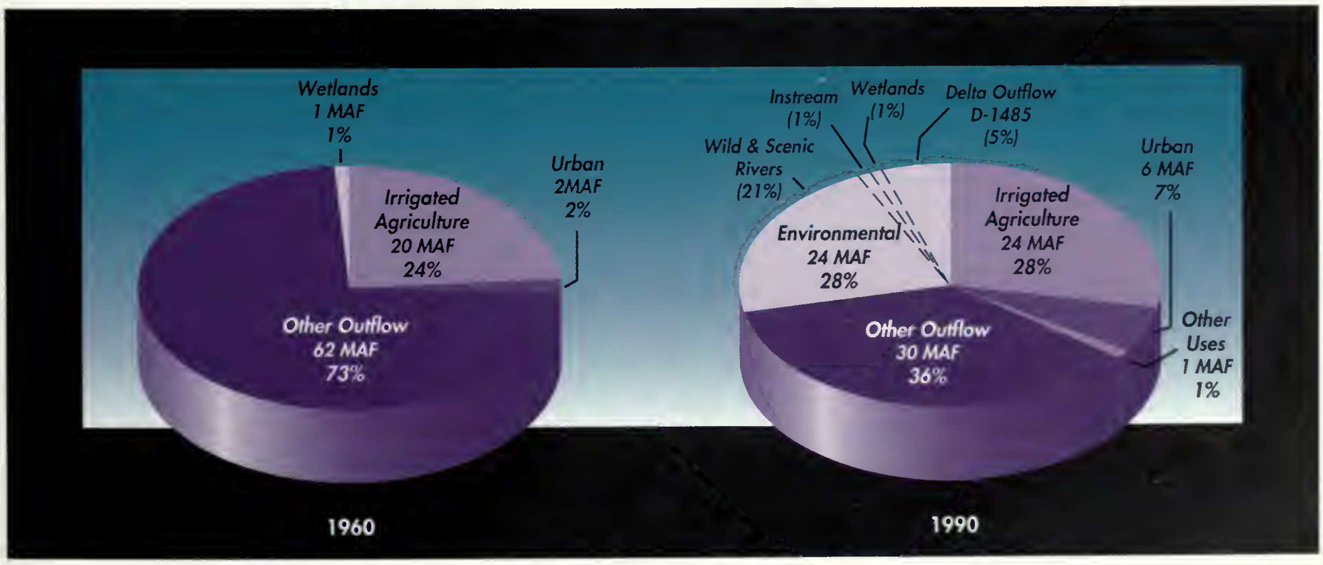


Figure ES-3. Disposition of Average Annual Water Supply

Figure ES-4. Major Water Project Facilities in California

could decrease by roughly 1 to 3 maf because of potential operational and institutional changes discussed in Chapter 1.

As Arizona and Nevada continue to use more of their allocated Colorado River supplies, imports to the South Coast Region for urban and agricultural uses could eventually decline from about 5.2 to 4.4 maf annually, which is California's allocated Colorado River supply. (See Figure ES-4 for locations of major water project facilities in California.) In past years, Arizona and Nevada had been using less than their share of Colorado River water, and their unused supply was made available to California. Southern California was spared from severe rationing during most of the 1987–92 drought primarily because of the 600,000 af annually of unused Colorado River water made available to the Metropolitan Water District of Southern California. Even with this supply, however, much of Southern California experienced significant rationing in 1991. Supplemental Colorado River water cannot be counted on to meet needs in the future as Arizona and Nevada continue to use more of their Colorado River allocations.

The 1987–92 drought induced many creative approaches for coping with water shortages throughout California, including construction of more interconnections between local, State, and federal water delivery facilities. The City of San Francisco's connection to the State Water Project's South Bay Aqueduct allowed emergency drought supplies to be conveyed into the city's system. Toward the end of the drought, the City of Santa Barbara constructed a sea water desalting facility and received limited SWP supplies through an emergency interconnection and a series of exchanges with other water agencies. Throughout California, water agencies were buying and exchanging water to meet critical needs. The State Drought Water Bank played a vital role in meeting some of those critical needs.

Prior to changes in water allocations from the Sacramento–San Joaquin and Colorado river systems, California had roughly enough water to meet average annual urban and agricultural water demands at the 1990 level while complying with existing SWRCB standards, as specified in D–1485. Table ES-1 shows California's water supply with existing facilities and programs as operated in accordance with D–1485.

Average annual supplies at the 1990 level of development are about 63.5 maf (includes natural flows dedicated for instream use and ground water overdraft) and could decrease to 63 maf by 2020 without any additional facilities or programs. A possible

California's Water Supply Availability

Average year supply is the average annual supply of a water development system over a long period. For this report the SWP and CVP average year supply is the average annual delivery capability of the projects over a 70-year study period (1922-91). For a local project without long-term data, it is the annual average deliveries of the project during the 1984-1986 period. For dedicated natural flow, it is the long-term average natural flow for wild and scenic rivers, or it is environmental flows as required for an average year under specific agreements, water rights, court decisions, and congressional directives.

Drought year supply is the average annual supply of a water development system during a defined drought period. For this report, the drought period is the average of water years 1990 and 1991. For dedicated natural flow, it is the average of water years 1990 and 1991 for wild and scenic rivers, or it is environmental flows as required under specific agreements, water rights, court decisions, and congressional directives.

Table ES-1. California Water Supplies with Existing Facilities and Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(millions of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	10.1	8.1	10.1	8.1	10.2	8.3	10.3	8.4
Local imports(1)	1.0	0.7	1.0	0.7	1.0	0.7	1.0	0.7
Colorado River	5.2	5.1	4.4	4.4	4.4	4.4	4.4	4.4
CVP	7.5	5.0	7.7	5.1	7.7	5.2	7.7	5.2
Other federal	1.2	0.8	1.3	0.8	1.3	0.8	1.3	0.8
SWP(1)	2.8	2.1	3.2	2.0	3.3	2.0	3.3	2.0
Reclaimed	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ground water(2)	7.1	11.8	7.1	12.0	7.2	12.1	7.4	12.2
Ground water overdraft(3)	1.3	1.3	—	—	—	—	—	—
Dedicated natural flow	27.2	15.3	27.4	15.4	27.4	15.4	27.4	15.4
TOTAL	63.5	50.4	62.4	48.9	62.7	49.1	63.0	49.4

(1) 1990 SWP supplies are normalized and do not reflect additional supplies delivered to offset the reduction of supplies from the Mono and Owens basins to the South Coast hydrologic region.
(2) Average ground water use is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into the ground water basins.
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

800,000–af reduction in Colorado River supplies could be offset by short–term transfers and increased SWP Delta diversions, in addition to water management programs of the MWDSC. The 1990 level drought year supplies are about 50.4 maf and could decrease about 1 maf by 2020 without additional storage and water management options. However, until solutions to complex Delta problems are identified and implemented, Delta diversions will continue to be impaired.

Annual reductions in total water supply for urban and agricultural uses could be in the range of 500,000 af to 1 maf in average years and 2 to 3 maf in drought years. These reductions result mainly from compliance with the ESA biological opinions and proposed EPA Bay-Delta standards. Until a Delta solution that meets the needs of urban, agricultural, and environmental interests is identified and implemented, there likely will be water supply shortages in both dry and average years.

Bulletin 160–93 analyses found that baseline hydrologic and water development data used in preparing statewide supply and demand balances need to be updated. The last major inventory of such conditions was Bulletin 1, *Water Resources of California*, published in 1951. Bulletin 160–93 thus recommends that DWR should initiate work to update and maintain this resource document to incorporate more recent hydrologic data, including 40 more years of runoff data.

Ground Water

California's ground water storage in some 450 ground water basins statewide is about 850 maf, roughly 100 times the State's annual net ground water use. Probably less than half of the ground water is usable because of quality considerations and the cost of extraction. However, the large quantity of good quality ground water in storage makes it a crucial component of California's total water supply. Ground water played a vital role in helping the State through the 1987–92 drought.

Figure ES-5. Components of Ground Water Use and Sources of Recharge

In a year of average precipitation and runoff, an estimated 15 maf of ground water is extracted and applied for agricultural, municipal, and industrial use. There is a substantial amount of ground water recharge from surface water and ground water used to irrigate agricultural crops. Some of the irrigation water flowing in unlined ditches and some of the water that is applied to irrigate crops infiltrates into the soil, percolates through the root zone and recharges the ground water basins (see Figure ES-5).

The annual net use of ground water is ground water extraction minus deep percolation of applied water. The 1990 statewide average annual net ground water use was about 8.4 maf. The use of prime supply from ground water basins for 1990 was about 7.1 maf, and the remaining 1.3 maf was overdrafted from the basins. (*Ground water prime supply* is the long-term average annual percolation into major ground water basins from precipitation and from flows in rivers and streams.) Table ES-2 shows 1990 level use of ground water and overdraft by hydrologic region. The amounts shown include an estimated 200,000 af of overdraft resulting from possible degradation of ground water quality in adjacent basins located in the trough of the San Joaquin Valley. Poor quality ground water moves eastward, displacing good quality ground water in the trough of the valley. The concentration of total dissolved solids in the valley 's west side ground water generally ranges from 2,000 to 7,000 milli-

Table ES-2. Use of Ground Water by Hydrologic Region, 1990
(thousands of acre-feet)

Hydrologic Region	*Ground Water Use*		*Ground Water Overdraft*
	average	*drought*	
North Coast	263	283	0
San Francisco Bay	100	139	0
Central Coast	688	762	240
South Coast	1,083	1,306	20
Sacramento River	2,496	2,865	30
San Joaquin River	1,098	2,145	210
Tulare Lake	915	3,773	650
North Lahontan	121	146	0
South Lahontan	221	252	70
Colorado River	80	80	80
STATEWIDE	7,100	11,800	1,300

grams per liter: TDS in the valley's east side basin ranges from 300 to 700 milligrams per liter.

Annual ground water overdraft has diminished to about two-thirds of what it was in 1980 (when ground water overdraft was last studied), from roughly 2 maf in 1980 to about 1.3 maf in 1990. This reduction has mainly occurred in the San Joaquin Valley and is due to the benefits of imported supplies to the San Joaquin River and Tulare Lake regions; construction and operation of new reservoirs in the San Joaquin River Region during the 1960s and 1970s; and prudent surface and ground water management, including conjunctive use of these supplies. However, until key Delta issues are resolved and additional water management programs are implemented, the reductions in overdraft seen in the San Joaquin Valley during the last decade will reverse as more ground water is pumped to make up for lost surface water supplies, some of which formerly came from the Delta. In the long–term, continued overdraft is not sustainable. As such, overdraft is not included as a future supply.

Conjunctive use operations, which helped reduce ground water overdraft, will continue to be refined and made more effective in the future. Efficient use of surface and ground water through conjunctive use programs has become an extremely important water management tool. Such programs are generally less costly and cause fewer adverse environmental impacts than traditional surface water projects because they increase the efficiency of existing supply systems without requiring major facility additions. However, conjunctive use programs must address potentially undesirable results such as loss of native vegetation and wetland habitat, adverse effects on third parties and fish and wildlife, land subsidence, and degradation of water quality in the aquifer.

Bulletin 160–93 recommends that the State encourage efforts to develop ground water management programs at the local and regional levels and to remove legal, institutional, financial, and other barriers that limit conjunctive use of ground water basins. The programs should be focused on solutions to clearly identified problems, such as overdraft, and natural and human–caused contamination so as to optimize

the use of surface and ground water resources. Specific recommendations are as follows:

1. Local agencies should adopt programs for ground water management with the following goals:

   a. Identify and protect major natural recharge areas. Develop managed recharge programs where feasible.

   b. Optimize use of ground water storage conjunctively with surface water, including storage of recycled water and imported sources.

   c. Increase monitoring of ground water quality to improve the ability to assess and respond to water degradation problems. Report trends in the chemical contents of ground water.

   d. Develop ground water basin management plans that not only manage supply, but also address overdraft, increasing salinity, chemical contamination, and subsidence.

   e. Adopt and implement a public education program to ensure that citizens understand the importance of ground water and steps they can take to protect and enhance their water supply.

2. Continuing use of overdraft as a source of supply is not sustainable and thus must be addressed in State and local water management plans. Options for addressing the management of overdraft will be strongly influenced by the availability of supplies and economic factors that must be considered in such plans.

Water Quality

Water quality directly affects the quantities of water available for use in California. Poor water quality has inherent costs, such as treatment and storage costs for drinking water, reduced crop yields, higher handling costs, and damage to fish and wildlife. Avoiding these costs by protecting water sources from degradation in the first place is one of California's more pressing water management problems.

Of critical importance to many Californians is the water quality of the Sacramento–San Joaquin Delta. Water soluble minerals, municipal and industrial waste discharges, and agricultural drainage increase the salt content of water as it flows from higher elevations to the Delta. Sea water intrusion is a major source of salts in Delta water supplies. Bromides from sea water are of particular concern because in combination with dissolved organic compounds present in soil, bromides contribute to the formation of harmful disinfection byproducts during water treatment processes. On average, Delta influences are responsible for elevating the salt concentration at Banks Pumping Plant to about 150 milligrams per liter above that of the fresh water inflows to the Delta. Most of the Delta water quality objectives relate to salinity. The SWP and CVP are required to release sufficient fresh water to meet Delta salinity standards.

Numerous aspects of water quality can affect fish and wildlife habitat and result in monetary or environmental costs. An example is selenium in agricultural drainage

from the San Joaquin Valley which was used to supply wetland habitat in the valley. In this case, elevated selenium concentrations caused severe reproductive damage to fish and wildlife species, particularly to birds using the wetlands.

Human activities introduce a variety of pollutants that contribute to degradation of water quality. Mining can be a major source of acids and toxic metals. Agricultural drainage may contain chemical residues, toxic elements, salts, nutrients, and elevated concentrations of chemicals that cause harmful disinfection byproducts. Municipal and industrial discharges, including storm runoff, are regulated by State and federal environmental protection laws and policies. Waste water must be treated to render it free of certain disease–carrying organisms and reduce its environmental impact. Unfortunately, normal waste water treatment plant processes may not completely remove all water–borne synthetic chemicals. Increasingly, more stringent and costly water quality standards for public health are affecting the continued reliability and costs of water supplies.

Disease–causing organisms and other harmful microorganisms found in untreated water can pose serious health risks. Federal and State drinking water standards have been adopted to protect the health of consumers. The California Department of Health Services, Office of Drinking Water, promulgates and enforces State standards and enforces federal standards. Most drinking water quality standards are met by California's municipal drinking water utilities. However, some drinking water regulatory activities may conflict. For example, concern over surviving pathogens spurred a rule requiring more rigorous disinfection. At the same time, there is considerable regulatory concern over trihalomethanes and other disinfection byproducts, resulting from disinfection of drinking water with chlorine. The problem is that if disinfection is made more rigorous, disinfection byproduct formation is increased. Additionally, poorer quality source waters with elevated concentrations of organic precursors and bromides further complicate the problem of reliably meeting standards for disinfection while meeting standards for disinfection byproducts.

New and more costly federal and State surface water treatment rules (effective in June 1993) require that all surface water supplied for drinking receive filtration, high level disinfection, or both. The cost of constructing new filtration facilities to meet new regulations can be quite high. The U.S. Environmental Protection Agency estimates the annual nationwide cost of treating drinking water to meet existing and new standards will be $36 million a year in the early 1990s, $539 million annually by 1994, and will rise to $830 million, as a result of the need to make long–term capital investments, before stabilizing at $500 million a year by the year 2000. These estimates demonstrate that major costs will result from meeting the new standards. The regulatory community will have to carefully balance the benefits and risks associated with pursuing the goals of efficient disinfection and reduced disinfection byproducts. One essential corollary action will be to make any source water quality improvements that are feasible.

There are many water quality problems which can result in cost, either direct or environmental. In turn, these impacts reduce flexibility in water supply planning and management. California's record has been a good one, for an industrialized state. Most of our waters remain fit for fish and wildlife, and for multiple uses by people. However, the rapidly growing population and continued industrialization will continue to greatly challenge our ability to maintain and improve water quality. If we are to meet this challenge successfully, it will require the best efforts of government,

industry, and, most of all, concerned citizens. Bulletin 160–93 put forth the following recommendations about solving water quality problems:

1. Increasingly stringent and costly drinking water quality standards for public health protection will affect the continued availability and cost of water supplies. More effort must be made by State and federal agencies to balance the cost with public health and other benefits of such standards.

2. Research into relationships and effects of water quality degradation on fish and wildlife should continue. In particular, more information is needed on acute and chronic effects of low level toxicants on the health and reproductive capacity of aquatic organisms. (Research should be a cooperative effort by State and federal agencies.)

3. Urban water supplies diverted from the South Delta face the threat of increasing water quality degradation from both salinity intrusion and organic substances originating in Delta island drainage. Factors responsible for quality degradation from Delta island drainage should be investigated by State agencies, and potential means of mitigating problems identified.

4. Reuse of adequately treated waste water can, in some areas, provide alternative sources of supply as well as benefit fish and wildlife resources, particularly in arid portions of the State. Efforts by State agencies should be continued to define the conditions and degree of treatment needed to allow use of treated waste water for beneficial uses and discharge of effluents to water courses so that these benefits can be realized.

Definition of Terms

- **Applied water:** The amount of water from any source needed to meet the demand of the user. It is the quantity of water delivered to any of the following locations:
  - the intake to a city water system or factory.
  - the farm headgate.
  - a marsh or wetland, either directly or by incidental drainage flows; this is water for wildlife areas.
  - For existing instream use, applied water demand is the portion of the stream flow dedicated to in-stream use or reserved under the federal or State Wild and Scenic Rivers acts or the flow needed to meet salinity standards in the Sacramento-San Joaquin Delta under SWRCB standards.
- **Evapotranspiration:** The quantity of water transpired (given off) and evaporated from plant tissues and surrounding soil surfaces. Quantitatively, it is expressed in terms of volume of water per unit acre of depth of water during a specified period of time. Abbreviation: ET.
- **Evapotranspiration of applied water:** The portion of the total evapotranspiration which is provided by irrigation. Abbreviation: ETAW.
- **Irrecoverable losses:** The water lost to a salt sink or water lost by evaporation or evapotranspiration from conveyance facilities or drainage canals.
- **Net water demand:** The amount of water needed in a water service area to meet all the water service requirements. It is the sum of evapotranspiration of applied water in an area, the irrecoverable losses from the distribution system, and the outflow leaving the service area, including treated municipal outflow.
- **Depletion:** The water consumed within a service area and no longer available as a source of water supply. For agriculture and wetlands it is ETAW plus irrecoverable losses. For urban areas it is the exterior ETAW, sewage effluent that flows to a salt sink, and incidental ET losses. For instream needs it is the dedicated flow that proceeds to a salt sink.
- **Average year demand:** The demand for water under average weather conditions for a defined level of development.
- **Drought year demand:** The demand for water during a drought period for a defined level of development. It is the sum of average year demand and water needed for any additional irrigation of farms and landscapes due to the lack of precipitation or increase in evapotranspiration during drought.
- **Normalized demand:** The result of adjusting actual water use in a given year to account for unusual events such as dry weather conditions, government interventions for agriculture, rationing programs, etc.

Chapter 3

Water Demands

Extensive evaluation and analyses of water demands were conducted to complete Bulletin 160–93. These analyses recognize the water demands of all beneficial uses: urban, agricultural, environmental, and other uses including water based recreation and power generation. An overview of these demands follows.

Urban Water Demand

Urban water demand forecasts are primarily based on statewide population projections that show an increase of almost 19 million people from 1990 to 2020, from roughly 30 million to 49 million people. About half the projected population increase will happen in the South Coast Region. Population projections for the *California Water Plan Update* are based on the Department of Finance baseline series. The DOF population estimates are taken from the 1990 census as the base year. Figure ES-6 shows projections of population.

Urban annual net water demand could increase from 6,800,000 af in 1990 to 10,500,000 af by 2020, after accounting for implementation of conservation measures that are expected to reduce urban annual net water demand by about 900,000 af. Urban water demand forecasts are based on: population projections, unit urban water use values—considering probable effects of future water conservation measures, and housing trends, such as increases in multi-family housing and greater growth in warmer inland areas of the State. Table ES-3 shows urban water demand forecasts by hydrologic region.

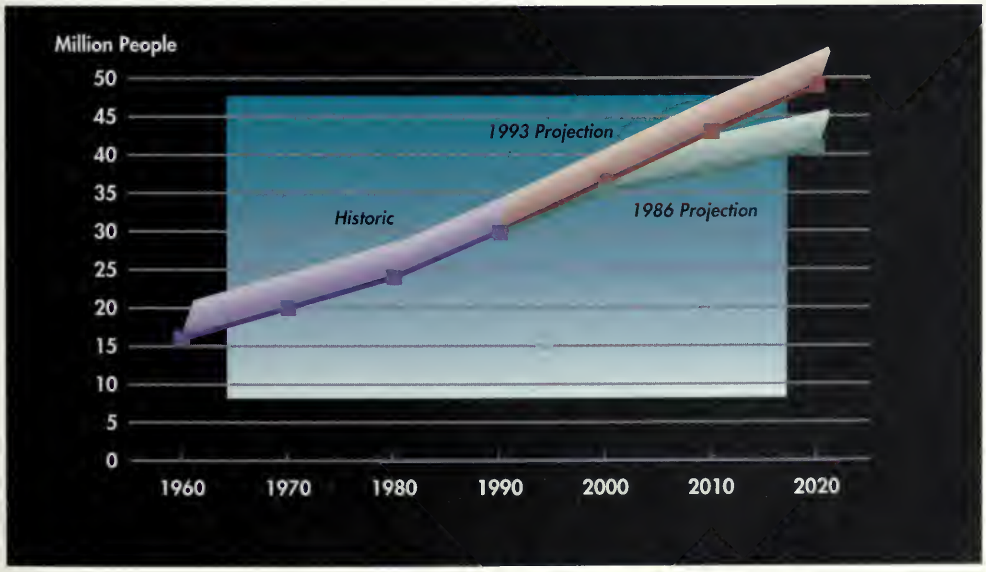


Figure ES-6. Comparison of Population Projections Used in Bulletin 160 Analyses

Table ES-3. Urban Water Demand by Hydrologic Region

(thousands of acre-feet)

Hydrologic Region	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
North Coast								
Applied water demand	168	177	186	195	204	214	219	230
Net water demand	168	177	186	195	204	214	219	230
Depletion	110	112	119	122	127	132	136	142
San Francisco Bay								
Applied water demand	1,186	1,287	1,298	1,390	1,365	1,486	1,406	1,530
Net water demand	1,186	1,287	1,298	1,390	1,365	1,486	1,406	1,530
Depletion	1,079	1,175	1,185	1,271	1,247	1,362	1,287	1,403
Central Coast								
Applied water demand	273	277	315	321	365	373	420	429
Net water demand	229	233	263	268	304	311	349	357
Depletion	203	206	235	239	272	278	315	321
South Coast								
Applied water demand	3,851	3,997	4,446	4,617	5,180	5,381	6,008	6,244
Net water demand	3,511	3,641	4,010	4,161	4,623	4,799	5,309	5,514
Depletion	3,341	3,463	3,536	3,677	3,993	4,158	4,596	4,785
Sacramento River								
Applied water demand	744	807	911	989	1,076	1,167	1,231	1,335
Net water demand	744	807	911	989	1,076	1,167	1,231	1,335
Depletion	236	257	293	318	349	378	400	434
San Joaquin River								
Applied water demand	495	507	663	684	839	867	1,029	1,063
Net water demand	353	366	468	490	587	616	717	752
Depletion	192	194	258	265	332	340	410	420
Tulare Lake								
Applied water demand	523	523	716	716	892	892	1,116	1,116
Net water demand	214	214	292	292	364	364	454	454
Depletion	214	214	292	292	364	364	454	454
North Lahontan								
Applied water demand	37	38	43	44	46	48	51	52
Net water demand	37	38	43	44	46	48	51	52
Depletion	14	15	17	18	19	20	21	21
South Lahontan								
Applied water demand	187	193	292	302	409	423	550	565
Net water demand	123	125	191	198	269	277	360	372
Depletion	123	125	191	198	269	277	360	372
Colorado River								
Applied water demand	301	301	399	399	512	512	621	621
Net water demand	204	204	272	272	349	349	424	424
Depletion	204	204	272	272	349	349	424	424
TOTAL								
Applied water demand	7,800	8,100	9,300	9,700	10,900	11,400	12,700	13,200
Net water demand	6,800	7,100	7,900	8,300	9,200	9,600	10,500	11,000
Depletion	5,700	6,000	6,400	6,700	7,300	7,700	8,400	8,800

Urban water agencies recognize the need for better demand forecasting methods to estimate water use. Some water agencies are moving toward a more disaggregated approach, similar to that of energy utilities. DWR and the University of California at Los Angeles have evaluated forecasting methods and developed procedures to estimate conservation from Best Management Practices. In this approach, data about the end uses of water are analyzed individually and then aggregated together to forecast overall water use. The benefits from implementing BMPs were evaluated and included in Bulletin 160 estimates of future urban water use. Statewide, implementation of BMPs could reduce urban annual applied water demand by about 1,300,000 af by 2020. The annual net water use and depletion reduction from BMPs could amount to 900,000 af and is included in the urban water demand forecasts shown in Table ES-3. The 900,000 af is in addition to 400,000 af of annual net savings resulting from conservation measures put in place between 1980 and 1990. However, more water use information must be gathered to further refine urban demand forecasting and evaluation of BMP effects on future water demand. Specific recommendations presented in Bulletin 160-93 are:

1. Urban water use forecasts require annual reporting of data to accurately estimate urban water use for residential, industrial, commercial and governmental sectors. Water use data reported to the State Controller's Office and the Department of Health Services, Office of Drinking Water, are currently insufficient to meet increasingly more complex forecasting needs. DWR should implement new reporting mechanisms for urban water use data.

2. Local land use planning and resulting General Plans should be coordinated with water resources planning agencies to insure compatibility between land use plans and water supply plans to make optimum use of the State's water resources.

3. DWR, in cooperation with the Urban Water Conservation Council, should determine cost–effectiveness and water savings (reduced depletions) resulting from the various urban Best Management Practices and identify additional urban practices for use in statewide and regional planning.

4. Urban "water price" effects and their relationship to conservation practices are not well understood and require further data collection and analysis to ascertain their effects on demand. It is recommended that efforts of the Urban Water Conservation Council and others be combined with an expanded program in DWR to address the issue.

Agricultural Water Demand

To compute agricultural water demand, Bulletin 160–93 analyses integrated the results of three forecasting methods used to estimate irrigated acreage and crop type:

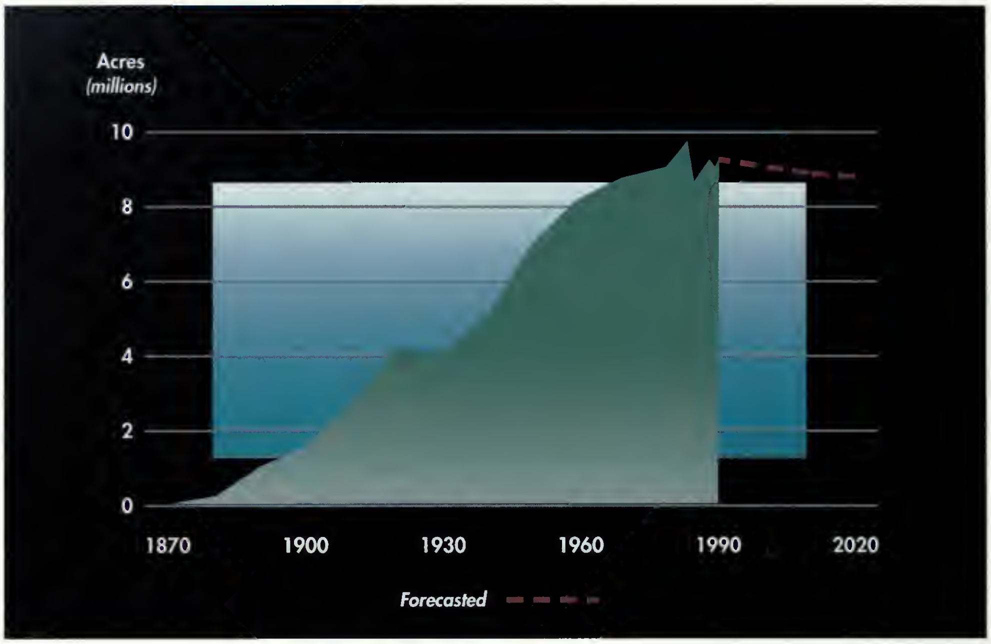
- Review of local historical crop acreage along with the availability of water and impacts of urban encroachment
- Crop Market Outlook
- Central Valley Production Model

Every five to seven years since 1948, DWR has physically surveyed agricultural land use to help assess the locations and amounts of irrigated crops. Acreages of crops grown are estimated on a yearly basis, using the annual crop data produced by county Agricultural Commissioners, adjusted on the basis of DWR land use surveys, and estimates of urban expansion onto irrigated agricultural land (see Figure ES-7).

The Crop Market Outlook is an economic model that uses data based on the expert opinion of bankers, farm advisors, commodity marketing specialists, and oth-

Figure ES-7. Irrigated Acreage in California 1870 – 2020

Note: The decline in 1983 was caused primarily by wet conditions and the federal agricultural payment in kind (PIK) program. The decline in 1987–90 was due to drought.



ers regarding trends in factors affecting crop production in California. Several factors are evaluated, but the four primary ones are: (1) the current and future demand for food and fiber by the world's consumers; (2) the shares of the national and international markets for agricultural productions that are met by California's farmers and livestock producers; (3) technical factors, such as crop yields, pasture carrying capacities, and livestock feed conversion ratios; and (4) competing output from dryland (non-irrigated) acres in other states. The results determine the forecasted future potential California production of various crops.

The Central Valley Production model is an economic model that accounts for crop production costs in different areas of the Sacramento and San Joaquin valleys in conjunction with the effect of overall production levels on the market prices for California crops. This helps to estimate how the total California production will be distributed among counties.

Some crop shifts are expected to happen as growers move from low price to high price crops. Alfalfa and pasture lands are forecasted to decrease by about 331,000 acres mostly in the San Joaquin and Tulare Lake regions. Crop acreages expected to increase include vegetables, nuts (almonds and pistachios), and grapes. While the acreage of low-quality (bulk) wine-grape acreage is decreasing in the San Joaquin Valley, the acreage of high-quality table wine grapes is increasing in other regions.

The 1990 level crop acreage and crop types are based on agricultural land use surveys which were normalized to take into account the impact of the 1987-92 drought, government set aside programs, and other annual crop acreage fluctuations. Forecasts of agricultural water needs are based on: (1) agricultural acreage forecasts, (2) crop type forecasts, (3) crop unit applied water and unit evapotranspiration of applied water values (in acre-feet for each crop acre), and (4) estimates of future water conservation.

Agricultural water needs were evaluated by determining crop types and acreages for each region. Forecasts indicate that irrigated agricultural acreage will decline by about 378,000 acres between 1990 and 2020, from 9,178,000 acres to about

Table ES-4. Agricultural Water Demand by Hydrologic Region
(thousands of acre-feet)

Hydrologic Region	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
North Coast								
Applied water demand	839	915	868	948	891	972	907	989
Net water demand	744	760	748	764	761	776	771	787
Depletion	592	647	611	669	627	686	637	698
San Francisco Bay								
Applied water demand	92	103	94	104	94	104	94	103
Net water demand	88	99	90	100	90	100	90	99
Depletion	80	89	82	90	82	90	82	89
Central Coast								
Applied water demand	1,140	1,178	1,166	1,206	1,182	1,220	1,189	1,233
Net water demand	893	961	910	982	920	991	921	1,003
Depletion	884	950	901	971	911	980	911	992
South Coast								
Applied water demand	727	753	632	655	499	518	382	396
Net water demand	644	668	569	592	458	474	356	370
Depletion	644	668	569	592	458	474	356	370
Sacramento River								
Applied water demand	7,848	8,645	7,698	8,517	7,592	8,475	7,558	8,333
Net water demand	6,788	7,394	6,602	7,222	6,506	7,184	6,497	7,049
Depletion	5,477	6,123	5,426	6,149	5,439	6,151	5,437	6,151
San Joaquin River								
Applied water demand	6,298	6,757	6,052	6,500	5,817	6,227	5,665	6,080
Net water demand	5,778	6,217	5,561	5,967	5,346	5,695	5,215	5,572
Depletion	4,719	5,064	4,605	4,909	4,490	4,777	4,383	4,678
Tulare Lake								
Applied water demand	9,613	9,849	9,306	9,518	9,075	9,281	8,833	9,038
Net water demand	7,723	7,895	7,518	7,685	7,347	7,505	7,169	7,320
Depletion	7,704	7,876	7,499	7,666	7,328	7,486	7,150	7,301
North Lahontan								
Applied water demand	522	587	523	589	525	591	536	602
Net water demand	460	511	458	510	457	508	469	521
Depletion	378	426	385	433	393	442	399	449
South Lahontan								
Applied water demand	317	321	266	270	258	262	253	257
Net water demand	290	293	242	245	235	238	231	234
Depletion	290	293	242	245	235	238	231	234
Colorado River								
Applied water demand	3,705	3,705	3,598	3,598	3,453	3,453	3,363	3,363
Net water demand	3,439	3,439	3,362	3,362	3,262	3,262	3,181	3,181
Depletion	3,439	3,439	3,362	3,362	3,262	3,262	3,181	3,181
TOTAL								
Applied water demand	31,100	32,800	30,200	31,900	29,400	31,100	28,800	30,400
Net water demand	26,800	28,200	26,100	27,400	25,400	26,700	24,900	26,100
Depletion	24,200	25,600	23,700	25,100	23,200	24,600	22,800	24,100

8,800,000 acres. This decline represents a 700,000–acre reduction from a peak in 1980.

Many of agriculture's unit applied water values have decreased during the past decade. For the State as a whole, agricultural annual net water demand will decrease by about 1.9 maf, from 26.8 maf in 1990 to 24.9 maf in 2020. Part of this decrease is due to improvements in irrigation efficiency and increased emphasis on water conservation since the 1976-77 drought. Table ES-4 shows the 1990 level and future agricultural water demands by hydrologic region. Bulletin 160–93 put forth the following recommendations for better assessing agricultural water demand:

1. State agencies should encourage and provide technical assistance to agricultural water suppliers in preparation and implementation of water management plans.
2. DWR needs to develop additional, more precise, on–farm applied–water data by crop to more accurately estimate agricultural applied water use efficiency in certain areas.
3. Studies need to be carried out by the State to determine the effect of increasing population on overall food production needs (in California and the nation) and their relationship to California's agricultural industry.

Environmental Water Demand

Estimates of environmental water demand are based on: water needs of managed fresh water wetlands and the Suisun Marsh, environmental instream flow needs, Delta outflow, and wild and scenic rivers. Wetlands water needs were tabulated from: (1) investigations of existing public and private wildlife refuges; and (2) additional water for wetlands as required by the CVPIA. Environmental instream flow needs were compiled by reviewing existing fishery agreements, water rights, and court decisions pertaining to water needs of aquatic resources of streams. Additional flows in the Trinity River, as noted in the CVPIA, are also included in forecasts of environmental instream demand.

Environmental water needs in drought years are considerably lower than in average years, reflecting the variability of the natural flows of rivers and lower fishery flow requirements, such as in D-1485 for the Bay–Delta. Table ES-5 shows California's regional environmental net water demands.

Figure ES-8. Environmental Water Needs (Average Year)

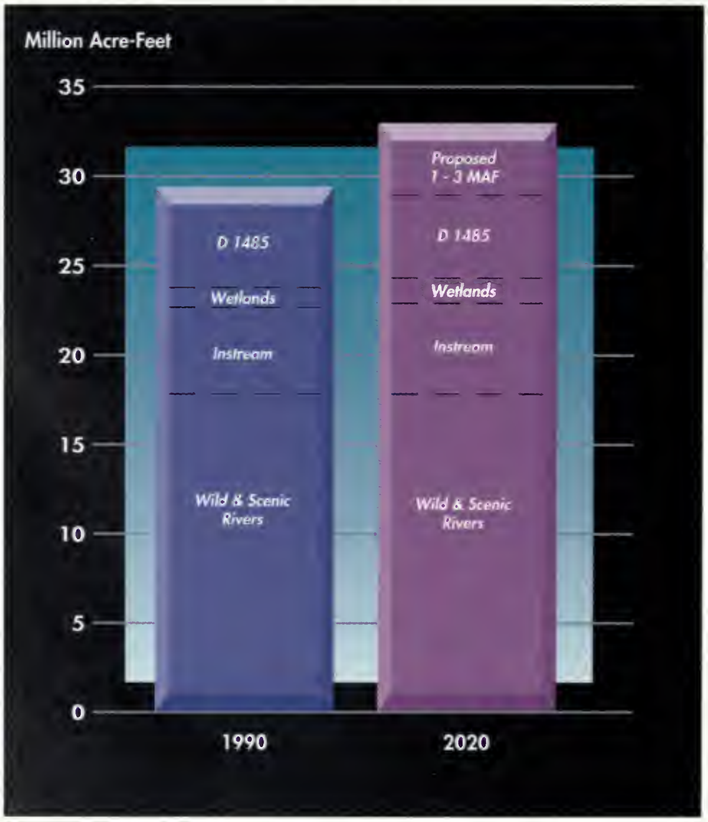


Table ES-5. Environmental Water Needs by Hydrologic Region
(thousands of acre-feet)

Hydrologic Region	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
North Coast								
Applied water demand(1)	19,199	9,299	19,326	9,426	19,326	9,426	19,326	9,426
Net water demand(1)	19,087	9,187	19,212	9,312	19,212	9,312	19,212	9,312
Depletion(1)	19,085	9,185	19,210	9,310	19,210	9,310	19,210	9,310
San Francisco Bay								
Applied water demand	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Net water demand	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Depletion	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Central Coast								
Applied water demand	4	2	4	2	4	2	4	2
Net water demand	1	0	1	0	1	0	1	0
Depletion	1	0	1	0	1	0	1	0
South Coast								
Applied water demand	2	2	6	6	6	6	6	6
Net water demand	2	2	6	6	6	6	6	6
Depletion	2	2	6	6	6	6	6	6
Sacramento River								
Applied water demand	3,927	3,493	4,117	3,638	4,117	3,638	4,117	3,638
Net water demand	3,717	3,299	3,860	3,442	3,860	3,442	3,860	3,443
Depletion	168	168	207	207	207	207	207	208
San Joaquin River								
Applied water demand	599	511	744	656	744	656	744	656
Net water demand	554	466	670	582	670	582	670	582
Depletion	190	190	306	306	306	306	306	306
Tulare Lake								
Applied water demand	82	82	136	136	136	136	136	136
Net water demand	34	34	56	56	56	56	56	56
Depletion	34	34	56	56	56	56	56	56
North Lahontan								
Applied water demand	17	17	17	17	17	17	17	17
Net water demand	17	17	17	17	17	17	17	17
Depletion	17	17	17	17	17	17	17	17
South Lahontan								
Applied water demand	128	122	128	122	128	122	128	122
Net water demand	128	122	128	122	128	122	128	122
Depletion	73	67	73	67	73	67	73	67
Colorado River								
Applied water demand	39	39	44	44	44	44	44	44
Net water demand	39	39	44	44	44	44	44	44
Depletion	39	39	44	44	44	44	44	44
TOTAL								
Applied water demand	28,800	16,800	29,300	17,300	29,300	17,300	29,300	17,300
Net water demand	28,400	16,400	28,800	16,800	28,800	16,800	28,800	16,800
Depletion	24,400	12,900	24,700	13,300	24,700	13,300	24,700	13,300

(1) Includes 17.8 MAF and 7.9 MAF flows for North Coast Wild and Scenic Rivers for average and drought years, respectively.

Regulatory agencies have proposed a number of changes in instream flow needs for major rivers, including the Sacramento and San Joaquin. These proposed flow requirements are not necessarily additive; however, an increase ranging from 1 to 3 maf is presented to envelop potential environmental water needs that could result from proposed additional instream flows and actions under way by regulatory agencies (see Figure ES-8). Bulletin 160-93 recommends the following to better assess environmental water needs:

1. Current methodologies for identifying cause and effect relationships for habitat and fishery populations need to be improved and new techniques developed and implemented by the State to better define environmental water needs.

2. DWR Bulletin 216, Inventory of Instream Flow Requirements related to stream diversions was last updated in 1982. An up–to–date inventory of flow requirements should be completed and maintained.

3. Water resources management for protection of fish and wildlife species should be planned and performed under a multi–species approach.

California's Total Water Demand

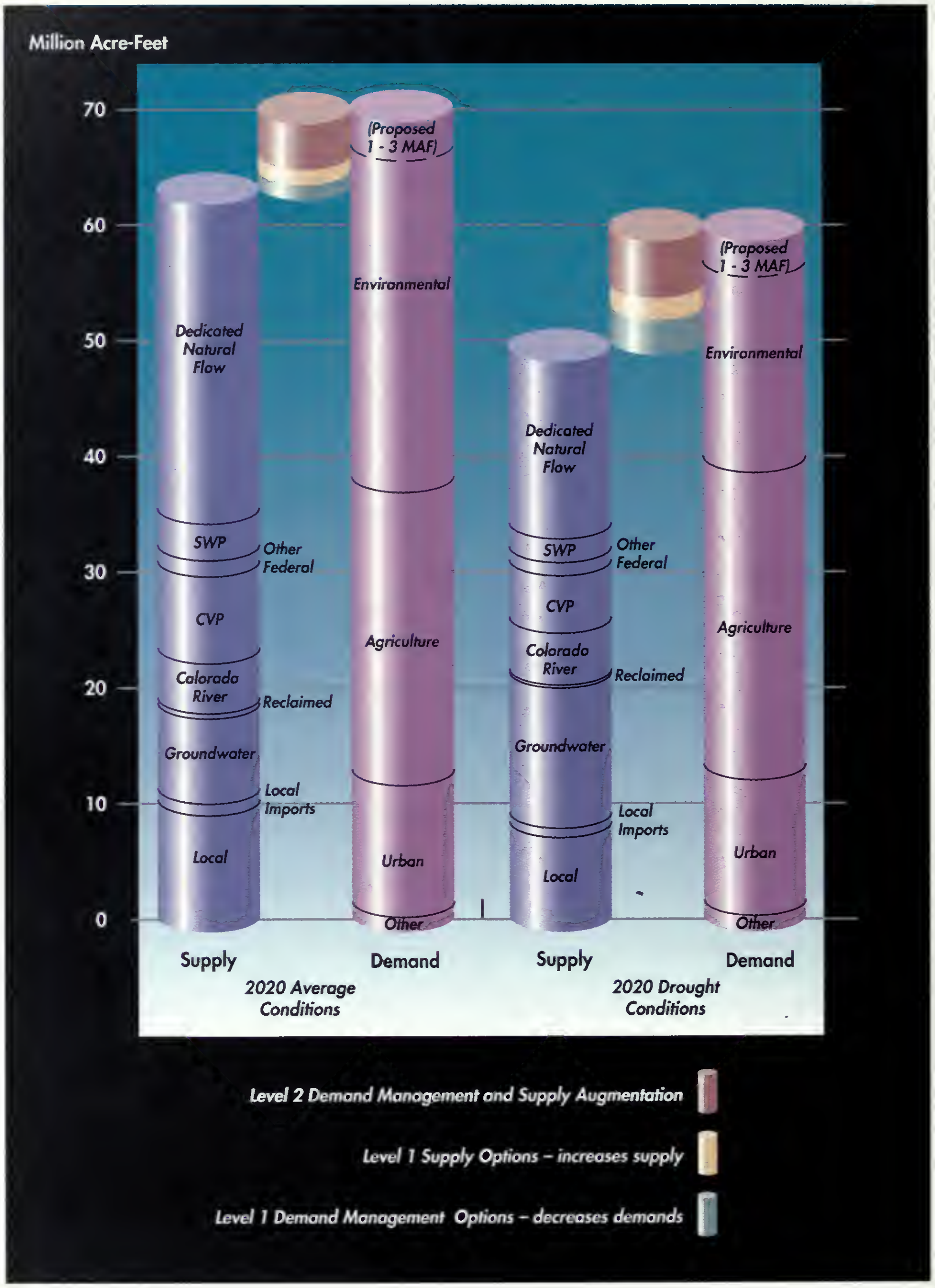
Table ES-6 shows California's net water demands; these include reductions in demand due to long–term conservation measures for both urban and agricultural users and reductions due to land retirement in San Joaquin Valley areas with poor drainage. A majority of the environmental net water demand occurs in the North Coast hydrologic region, indicating the large dedicated natural flows of the North Coast wild and scenic rivers system, about 17.8 maf in an average year. Dedicated instream flow under D-1485 makes up the largest portion of the San Francisco Bay Region's net water demand, about 4.6 maf, while urban and agricultural net water demands for the region amount to 1.3 maf. The South Coast Region has the highest net water demand for urban use, about 3.5 maf in an average year, and the Tulare Lake Region has the largest net water demand for agriculture, about 7.7 maf in an average year.

Table ES-6. California Water Demand
(millions of acre-feet)

Category of Use	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Urban								
Applied water demand	7.8	8.1	9.3	9.7	10.9	11.4	12.7	13.2
Net water demand	6.8	7.1	7.9	8.3	9.2	9.6	10.5	11.0
Depletion	5.7	6.0	6.4	6.7	7.3	7.7	8.4	8.8
Agricultural								
Applied water demand	31.1	32.8	30.2	31.9	29.4	31.1	28.8	30.4
Net water demand	26.8	28.2	26.1	27.4	25.4	26.7	24.9	26.1
Depletion	24.2	25.6	23.7	25.1	23.2	24.6	22.8	24.1
Environmental								
Applied water demand	28.8	16.8	29.3	17.3	29.3	17.3	29.3	17.3
Net water demand	28.4	16.4	28.8	16.8	28.8	16.8	28.8	16.8
Depletion	24.4	12.9	24.7	13.3	24.7	13.3	24.7	13.3
Other(1)								
Applied water demand	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Net water demand	1.5	1.5	1.5	1.4	1.5	1.4	1.5	1.4
Depletion	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TOTAL								
Applied water demand	68.0	58.0	69.1	59.2	69.9	60.1	71.1	61.2
Net water demand	63.5	53.2	64.3	53.9	64.9	54.5	65.7	55.3
Depletion	55.3	45.5	55.8	46.1	56.2	46.6	56.9	47.2

(1) Includes major conveyance facility losses, recreation uses, and energy production.

Figure ES-9. The California Water Balance



Chapter 4

Balancing Water Supply and Demand

California's average annual water supplies are generally adequate for today's average annual demands. However, during drought, present supplies are insufficient to meet present demands, as illustrated by the 2.7-maf shortage shown in the 1990 level drought scenario under D–1485 criteria for Delta supplies. In the 1991 and 1992 drought years, shortages caused urban mandatory water conservation (rationing), agricultural land fallowing and crop shifts, reductions in environmental flows, and short–term water transfers. As shown in the California Water Budget, Table ES-7, and in the California Water Balance, Figure ES-9, water shortages exist today.

As a result of altered water project operations to comply with biological opinions and the CVPIA, supplies for areas of the State relying on Delta exports are becoming more unreliable. EPA's (and other) proposed water quality standards could also reduce total water supply for urban and agricultural use by a range of 500,000 af to 1 maf in average years and 2 to 3 maf in drought years. While these amounts do not include potential reductions in Delta exports due to "take limits" under the biological opinions, they basically fall within the 1-to-3-maf range for proposed additional environmental demands. Such uncertainty of water supply delivery and reliability will continue until issues involving the Delta and other long–term environmental water management concerns are resolved.

Water managers are looking into a wide variety of management actions to supplement, improve, and make better use of existing resources. The single most important one will be solving key issues in the Delta. Some options for addressing the shortages and improving California's supply reliability are summarized here. After presenting the options, some local water supply and management issues (detailed in Volume II of the bulletin) are highlighted.

Options for Balancing Supply and Demand

Bulletin 160–93 presents both long–term and short–term supply augmentation and demand management options for meeting future needs. Included are short–term drought management options (demand reduction through urban rationing programs or water transfers that reallocate existing supplies through use of reserve supplies and agricultural land fallowing programs) and long–term demand management and supply augmentation options (increased water conservation, agricultural land retirement, additional waste water recycling, benefits of a long–term Delta solution, more conjunctive use programs, and additional south–of–the–Delta storage facilities). Future water management options are presented in two levels to better reflect the status of investigations required to implement them. Table ES-8 shows Level I demand management options, and Table ES-9 lists Level I water supply options.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a higher likelihood of being implemented by 2020.

Table ES-7. California Water Budget
(millions of acre-feet)

Water Demand/Supply	*1990* average	*1990* drought
Net Demand		
Urban—with 1990 level of conservation	6.8	7.1
—reductions due to long-term conservation measures (Level I)	0	0
Agricultural—with 1990 level of conservation	26.8	28.2
—reductions due to long-term conservation measures (Level I)	0	0
—land retirement in poor drainage areas of San Joaquin Valley (Level I)	—	—
Environmental	28.4	16.4
Other[1]	1.5	1.5
Subtotal	*63.5*	*53.2*
Proposed Additional Environmental Water Demands[2]		
Case I - Hypothetical 1 MAF	—	—
Case II - Hypothetical 2 MAF	—	—
Case III - Hypothetical 3 MAF	—	—
Total Net Demand	*63.5*	*53.2*
Case I	—	—
Case II	—	—
Case III	—	—
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies		
Developed Supplies		
Surface Water[3]	27.9	22.1
Ground Water	7.1	11.8
Ground Water Overdraft[3]	1.3	1.3
Subtotal	*36.3*	*35.2*
Dedicated Natural Flow	27.2	15.3
TOTAL Water Supplies	*63.5*	*50.5*
Demand/Supply Balance	*0.0*	*-2.7*
Case I	—	—
Case II	—	—
Case III	—	—
Level 1 Water Management Programs[4]		
Long-term Supply Augmentation		
Reclaimed	—	—
Local	—	—
Central Valley Project	—	—
State Water Project	—	—
Short-Term Drought Management		
Potential Demand Management	—	1.0
Drought Water Transfers	—	0.8
Subtotal - ***Level I Water Management Programs***	—	*1.8*
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	0.0
NET TOTAL Demand Reduction/Supply Augmentation	*0.0*	*1.8*
Remaining Demand/Supply Balance Requiring Level II Options	0.0	-0.9
Case I	—	—
Case II	—	—
Case III	—	—

(1) Includes major conveyance facility losses, recreation uses, and energy production.

(2) Proposed Environmental Water Demands—Case I-III envelop potential and uncertain demands and have immediate and future consequences on supplies from the Delta, beginning with actions in 1992 and 1993 to protect winter run salmon and delta smelt (actions which could also protect other fish species).

Table ES-7. California Water Budget
(millions of acre-feet)

2000		2010		2020	
average	*drought*	*average*	*drought*	*average*	*drought*
8.3	8.7	9.9	10.3	11.4	11.9
-0.4	-0.4	-0.7	-0.7	-0.9	-0.9
26.4	27.7	25.8	27.1	25.4	26.6
-0.2	-0.2	-0.3	-0.3	-0.4	-0.4
-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
28.8	16.8	28.8	16.8	28.8	16.8
1.5	1.4	1.5	1.4	1.5	1.4
64.3	*53.9*	*64.9*	*54.5*	*65.7*	*55.3*
1.0	1.0	1.0	1.0	1.0	1.0
2.0	2.0	2.0	2.0	2.0	2.0
3.0	3.0	3.0	3.0	3.0	3.0
—	—	—	—	—	—
65.3	54.9	65.9	55.5	66.7	56.3
66.3	55.9	66.9	56.5	67.7	57.3
67.3	56.9	67.9	57.5	68.7	58.3
27.8	21.5	28.1	21.6	28.2	21.7
7.1	12.0	7.2	12.1	7.4	12.2
—	—	—	—	—	—
34.9	*33.5*	*35.3*	*33.7*	*35.6*	*33.9*
27.4	15.4	27.4	15.4	27.4	15.4
62.3	*48.9*	*62.7*	*49.1*	*63.0*	*49.3*
—	—	—	—	—	—
-3.0	-6.0	-3.2	-6.4	-3.7	-7.0
-4.0	-7.0	-4.2	-7.4	-4.7	-8.0
-5.0	-8.0	-5.2	-8.4	-5.7	-9.0
0.5	0.5	0.6	0.6	0.8	0.8
0.0	0.1	0.0	0.3	0.0	0.3
0.0	0.0	0.0	0.0	0.0	0.0
0.2	0.1	0.6	1.0	0.7	1.0
—	1.0	—	1.0	—	1.0
—	0.8	—	0.8	—	0.8
0.7	*2.5*	*1.3*	*3.8*	*1.5*	*3.9*
0.1	0.0	0.1	0.2	0.1	0.2
0.7	*2.5*	*1.4*	*4.0*	*1.6*	*4.1*
—	—	—	—	—	—
-2.3	-3.5	-1.8	-2.4	-2.1	-2.9
-3.3	-4.5	-2.8	-3.4	-3.1	-3.9
-4.3	-5.5	-3.8	-4.4	-4.1	-4.9

(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

(4) Protection of fish and wildlife and a long-term solution to complex Delta problems will determine the feasibility of several water supply augmentation proposals and their water supply benefits.

Table ES-8. Level I Demand Management Options

Program	Applied Water Reduction (1,000 AF)	Net Water Demand Reduction (1,000 AF) average	drought	Economic Unit Cost ($/AF)[a]	Comments
Long-term Demand Management:					
Urban Water Conservation	1,300	900	900	315-390[b]	Urban BMPs
Agricultural Water Conservation	1,700	300	300	Not Available	Increased irrigation efficiency
Land Retirement	130	130	130	60	Retirement of land with drainage problems in west San Joaquin Valley; cost is at the Delta.
All American Canal Lining	68	68	68	—	Water conservation project; increases supply to South Coast Region
Short-term Demand Management:					
Demand Reduction	1,300	0	1,000	Not Available	Drought year supply
Land Fallowing/Short-term Water Transfers	800	0	800	125	Drought year supply; cost is at the Delta.

(a) Economic costs include capital and OMP&R costs discounted over a 50-year period at 6 percent discount rate. These costs do not include applicable transportation and treatment costs.
(b) Costs are for the ultra-low-flush toilet retrofit and residential water audit programs.

- Level II options are those programs that could fill the remaining gap shown in the balance between supply and urban, agricultural, and environmental water demands. These options require more extensive investigation and alternative analyses.

If all Level I options were implemented, there would still be a potential shortfall in annual supplies of about 2.1 to 4.1 maf in average years and 2.9 to 4.9 maf in drought years by 2020 that must be made up by Level II water supply augmentation and demand management programs. Table ES-10 shows California's water supplies with Level I water management programs. Table ES-11 lists Level II water management options.

After accounting for future reductions of 1.3 maf in net water demand resulting from implementation of urban Best Management Practices, agricultural Efficient Water Management Practices, and after accounting for another 100,000–af reduction due to future land retirement, forecasted 2020 net demand totals roughly 65.7 maf in average years and 55.3 maf in drought years. These demand amounts could increase by 1 to 3 maf, depending on the ultimate outcome of the CVPIA, the biological opinions, and other actions being taken to protect Delta water quality or threatened species.

By 2020, without additional facilities and improved water management, annual shortages of 3.7 to 5.7 maf could occur during average years, again depending on the outcome of various actions discussed in Chapter 1. Average year shortages are considered chronic and indicate the need for implementing long–term water supply augmentation and demand management measures to improve water service reliability. Similarly, by year 2020, annual drought year shortages could increase to 7.0 to 9.0 maf under D–1485 criteria, also indicating the need for long–term measures in addition to short–term drought management measures.

Table ES-9. Level I Water Supply Management Options

Program	Type	Capacity (1,000 AF)	Annual Supply (1,000 AF) average	Annual Supply (1,000 AF) drought	Economic Unit Cost ($/AF)[1]	Comments
Statewide Water Management:						
Long-term Delta Solution	Delta Water Management Program	—	200	400	Not Available	Under study by Bay/Delta Oversight Council; water supply benefit is elimination of carriage water under D-1485.
Interim South Delta Water Management Program	South Delta Improvement	—	60	60	60	Final draft is scheduled to be released in late 1994
Los Banos Grandes Reservoir[2 & 7]	Offstream Storage	1,730[3]	250-300	260	260	Schedule now coincides with BDOC process
Kern Water Bank[7]						
Kern Fan Element	Ground Water Storage	1,000	90	140	105-155	Evaluation under way
Local Elements	Ground Water Storage	2,000	90	290	180-460	Schedule now coincides with BDOC process
Coastal Branch–Phase II (Santa Ynez Extension)	SWP Conveyance Facility	57	N/A	N/A	630-1,110	Notice of Determination was filed in July 1992; construction began in late 1993.
American River Flood Control[4]	Flood Control Storage	545[3]	—	—	—	Feasibility report and environmental documentation completed in 1991.
Local Water Management:						
Water Recycling	Reclamation	1,321	923	923	125-840	New water supply
Ground Water Reclamation	Reclamation	200	100	100	350-900	Primarily in South Coast
El Dorado County Water Agency Water Program	Diversion from South Fork American River		24	23[5]	280	Certified final Programmatic EIR identifying preferred alternative; water rights hearings, new CVP contract following EIR/EIS preparation
Los Vaqueros Reservoir-Contra-Costra Water District	Offstream Storage Emergency Supply Water Quality	100	N/A	N/A	320-950	EIR certified in October 1993, 404 permit issued in April 1994.
EBMUD	Conjunctive Use and Other Options		N/A	43	370	Final EIR certified in October 1993
New Los Padres Reservoir-MPWMD	Enlarging existing reservoir	24	22	18	410	T&E species, steelhead resources, cultural resources in Carmel River
Domenigoni Valley Reservoir-MWDSC	Offstream storage of SWP and Colorado River water, drought year supply	800	0	264	410	Final EIR certified
Inland Feeder-MWDSC	Conveyance Facilities	—	—	—	—	
San Felipe Extension-PVWA	CVP Conveyance Facility		N/A	N/A[5]	140	Capital costs only; convey 18,000 AF annually
City of San Luis Obispo-Salinas Reservoir	Enlarging existing reservoir	18	—	1.6	—	Final EIR is expected to be certified in 1994.

(1) Economic costs include capital and OMP&R costs discounted over a 50-year period at 6 percent discount rate. These costs do not include applicable transportation and treatment costs.
(2) Annual supply and unit cost figures are based on Delta water supply availability under D-1485 with an Interim South Delta Water Management Program in place.
(3) Reservoir capacity.
(4) Falsom Lake flood control reservation would return to original 0.4 MAF.
(5) Yield of this project is in part or fully comes from the CVP.
(6) N/A: Not Applicable
(7) These programs are only feasible if a Delta Water Management Program is implemented.

Table ES-10. California Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(millions of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	10.1	8.1	10.2	8.2	10.2	8.3	10.3	8.4
Local imports(1)	1.0	0.7	1.0	0.8	1.0	1.0	1.0	1.0
Colorado River	5.2	5.1	4.4	4.4	4.4	4.4	4.4	4.4
CVP	7.5	5.0	7.7	5.2	7.7	5.2	7.7	5.2
Other federal	1.2	0.8	1.3	0.8	1.3	0.8	1.3	0.8
SWP(1)	2.8	2.1	3.4	2.1	3.9	3.0	4.0	3.0
Reclaimed	0.2	0.2	0.7	0.7	0.8	0.8	0.9	0.9
Ground water(2)	7.1	11.8	7.1	11.9	7.2	12.2	7.3	12.3
Ground water overdraft(3)	1.3	1.3	—	—	—	—	—	—
Dedicated natural flow	27.2	15.3	27.5	15.4	27.5	15.4	27.5	15.4
TOTAL	63.5	50.4	63.3	49.5	64.0	51.2	64.5	51.6

(1) 1990 SWP supplies are normalized and do not reflect additional supplies delivered to offset the reduction of supplies from the Mono and Owens basins to the South Coast hydrologic region.
(2) Average ground water use is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into the ground water basins.
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Water shortages would vary from region to region and sector to sector. For example, the South Coast Region's population is expected to increase to over 25 million people by 2020, requiring an additional 1.8 maf of water each year. Population growth and increased demand, combined with a possibility of reduced supplies from the Colorado River, mean that the South Coast Region's annual shortages for 2020 could amount to 400,000 af in average years and 1 maf in drought years. All told, forecasted shortages will be larger if solutions to complex Delta problems are not found, proposed local water management programs are not implemented, and additional facilities for the SWP are not constructed.

Local Water Management Issues

Local surface water development includes direct stream diversions as well as supplies in local storage facilities. As a result of economic, environmental, and regulatory obstacles, local agencies are finding it difficult to undertake new water projects to meet their needs where supply shortfalls exist or are forecasted. Thus, many local and regional water agencies are advocating or implementing incentive programs for water conservation to reduce demand where such programs are cost effective. Implementation of urban Best Management Practices and agricultural Efficient Water Management Practices will reduce demands in the future, and reductions caused by these practices were incorporated into Bulletin 160–93 water demand forecasts to 2020. Following are highlights of some local water supply issues covered in Volume II of the bulletin.

In the North Coast Region, a number of smaller communities have continuing water supply reliability problems, often related to the lack of economic base to support water management and development costs. Small communities along the coast, such as Moonstone, Smith River, and Klamath, either experience chronic water shortages or have supplies inadequate to meet projected growth. Water use is already

Table ES-11. Level II Water Management Options

Program	*Type*	*Supply Augmentation or Demand Reduction (1,000 AF)*	*Comments, Concerns, Problems*
Demand Management:			
Agricultural Water Conservation	Demand Reduction	300 (a)	Increased agricultural water use efficiency
Urban Water Conservation	Demand Reduction	220 (a)	Increased urban water use efficiency
Land Retirement	Demand Reduction	477 (a)	Retirement of land with poor drainage disposal in west side San Joaquin Valley
Water Transfer	—	800 (b)	Institutional constraints
Statewide Supply Management:			
Stanislaus-Calaveras River Water Use Program	Conjunctive Use	80 (c)	DWR, USBR, and local agencies are conducting studies.
Sacramento Valley Conjunctive Use Program	Conjunctive Use	100 (c)	Initial studies under way by DWR and local agencies.
Red Bank Project	Storage	40 (c)	
Shasta Lake Enlargement	Storage	1,450 (c)	
Clair Engle Lake Enlargement	Storage	700 (c)	
Westside Sacramento Valley Project	Conveyance	—	
Westside Reservoirs	Storage	up to 2,000 (c)	
Mid-Valley Canal	Conveyance	—	
Folsom South Canal Extension	Conveyance	—	
American River Water Resources Investigation	Storage	—	
Local Water Management:			
Use of Gray Water	Reclamation	180 (c)	Requires investment in separate plumbing; health concerns.
Water Recycling	Reclamation	370 (c)	Estimated ultimate potential
Water Desalting	Reclamation	390 (c)	
Reuse of Agricultural Brackish Water	Reclamation	—	High salt accumulation in soil
San Diego County Water Authority Water Resources Plan	Variety of Programs	85 (c)	Plan includes water recycling, ground water development, and desalination of brackish water.
Santa Clara Valley Water Management	—	—	Studies by district in progress; will need 100,000-150,000 AF additional supplies by 2020.
Delta Storage	Storage	—	Water quality, THM concerns
Watershed Management	—	100 (c)	Increases runoff from the watershed, environmental concerns.

(a) Reduction in applied water.
(b) Reallocation of supply for short- or long-term transfers.
(c) Average annual supply.

low due to conservation, so most of these problems will have to be solved by either constructing or upgrading community water systems.

In the San Francisco Bay Region, Marin Municipal Water District has relied, in part, on imported supply from Sonoma County Water Agency and extensive conservation efforts by its customers to ensure adequate supplies throughout the

recent drought. Under 2025 demand conditions, without supplemental supplies, the district estimates a 40–percent deficiency once every 10 years. To improve reliability, MMWD has negotiated an agreement with SCWA to import an additional 10,000 af. This supplemental supply, in conjunction with the district's water conservation and water management plans, should limit water shortages to about 10 percent once every 10 years.

Imported supplies by the City of San Francisco, Santa Clara Valley Water District, and East Bay Municipal Utilities District also suffered deficiencies during the recent drought. During 1991, the City of San Francisco was able to reduce expected rationing from 45 to 25 percent through purchases of 50,000 af from the 1991 State Drought Water Bank and 20,000 af from Placer County Water Agency. Customers were still required to reduce indoor use by 10 percent and outdoor use by 60 percent. During 1989-91, Santa Clara Valley Water District was able to get through with 25 percent rationing by purchasing 69,000 af from Yuba County, 14,000 af from Placer County and 20,000 af from the State Drought Water Bank.

Water supplies in much of the Central Coast Region are greatly dependent upon the region's ground water basins; the storage in these basins is small and fluctuates from year to year. Since ground water and limited local surface supplies are its primary source of water, the region is vulnerable to droughts. As ground water extractions exceed ground water replenishment, several of the region's coastal aquifers are in overdraft, allowing sea water intrusion. The recent drought required many communities in the region to implement stringent water conservation programs. The cities of Santa Barbara and Morro Bay constructed sea water desalination plants to improve their water service reliability.

The South Coast Region is home to more than one half of the State's population, 16 million people. The region's population is expected to increase to more than 25 million people by 2020. Such growth poses several critical water supply difficulties, most notably increased demand with limited ability to increase supply. Further, imports from Mono Lake tributaries, Owens Valley, and the Colorado River will be reduced and limits placed on Delta exports could further reduce water service reliability in the South Coast Region. MWDSC has several programs in progress to improve its water delivery and supply capability, including the construction of Domenigoni Valley Reservoir, and supports improved Delta transfer capabilities to improve reliability of its SWP supplies.

Court ordered restrictions on diversion from the Mono Basin and Owens Valley in the South Lahontan Region have reduced the amount of water the City of Los Angeles can receive. These restrictions affect South Coast Region supplies while improving the reliability of supplies for meeting environmental needs in the South Lahontan Region.

Sacramento River Region water users are concerned about protecting their area's ground water resources from export. Organized ground water management efforts in the region are currently under way in Butte, Colusa, Glenn, Shasta, Tehama, and Yolo counties. Also, several foothill areas that rely heavily on ground water are finding those supplies limited. With many people relocating to these areas, concern about ground water availability and the potential for its contamination is increasing.

Flood protection is another major concern for the region, especially along the Sacramento and American rivers near Sacramento. In 1991, the U.S. Army Corps of Engineers completed a feasibility report and environmental documentation for a flood

detention dam at the Auburn site in combination with levee modification along the lower American River to increase flood protection for the Sacramento area. The report, however, generated much controversy over whether Auburn Dam should be a flood detention only (dry dam) or multipurpose dam.

Foothill areas of both the San Joaquin River and Tulare Lake regions share the Sacramento River Region's problem of limited water supplies. Major concerns for this region's agricultural community are agricultural drainage disposal and treatment costs and potential reduction of imported supplies. CVP supplies will be reduced by the CVPIA, and both the CVP and SWP supplies are affected by ESA biological opinions and other actions proposed to protect Delta water quality and fisheries. Ground water overdraft in these regions will most likely increase because formerly–available surface supplies that recharged ground water basins may not return to former amounts.

In the North Lahontan Region years of disputes over the waters of the Truckee and Carson rivers led to the 1990 enactment of the Truckee-Carson-Pyramid Lake Water Rights Settlement Act. This federal act makes an interstate allocation of the rivers between California and Nevada, provides for the settlement of certain Native American water rights claims, and provides for water supplies for specified environmental purposes in Nevada. The act allocates to California: 23,000 af annually in the Lake Tahoe Basin, 32,000 af annually in the Truckee River Basin below Lake Tahoe, and allocations corresponding to existing water uses in the Carson River Basin. Provisions of the Settlement Act, including the interstate water allocations, will not take effect until several conditions are met, including negotiation of the Truckee River Operating Agreement required by the act.

Water exports from the South Lahontan Region have been the subject of litigation since the early 1970s. In 1972, the County of Inyo sued the City of Los Angeles claiming that increased ground water pumping for export was harming the Owens Valley. Consequently, the City of Los Angeles and Inyo County implemented enhancement projects to mitigate the impacts of ground water pumping. In 1989, the parties reached agreement on the long-term ground water management plan for Owens Valley and the EIR was accepted by the court.

Another long standing issue is the Los Angeles Department of Water and Power diversions from Mono Lake tributaries and the impact of these diversions on the lake level. As a result of extensive litigation between the City of Los Angeles and a number of environmental groups, LADWP is now prohibited by court order from diverting from the tributaries until the lake level stabilizes. SWRCB concluded Mono lake water rights hearings in February 1994. A draft decision regarding lake levels and stream flows on the four tributaries is expected in late 1994. The Mono–Owens system provided 17 percent of LADWP's water supply and 1.5 percent of its hydroelectric energy supply. Replacement water and energy are being sought. One source of replacement water will be four water reclamation projects to be funded by the Environmental Water Fund, which was created by the Legislature in 1989 to fund projects mutually agreed upon by LADWP and the Mono Lake Committee.

The Colorado River Region faces increasingly difficult issues involving water quality. In the late 1960s, 1970s, and early 1980s, the Salton Sea suffered from high water levels caused by increased agricultural runoff, treated urban waste water, and above average rainfall. In 1984, the State Water Resources Control Board adopted Water Right Decision 1600, which required Imperial Irrigation District to prepare a conservation plan and take other steps to improve its delivery system. Following a

1988 SWRCB order, IID implemented a program with funds provided by MWDSC to conserve water. The sea level has stabilized somewhat during recent years, due in part, to IID's conservation measures. The Salton Sea dilemma illustrates the complexity and opportunities for cooperative solutions of water management issues in California.

Chapter 5

Conclusions and Recommendations

Considering that much of the hypothetical range for additional environmental water has now been mandated by the biological opinions and CVPIA, or formally proposed in EPA Bay–Delta water quality standards, California faces more frequent and severe water supply shortages for the year 2000 and beyond. In 1993, an above normal water year, some CVP contractors had their supplies cut by 50 percent. These unanticipated shortages point to the need for a quick resolution of Delta problems through federal cooperation and participation. They also emphasize the need to move forward with demand management and supply augmentation programs at both statewide and local levels. The major conclusions and recommendations in Bulletin 160–93 follow.

Conclusions

- California's population is projected to increase to 49 million people by 2020 (from about 30 million in 1990). Even with extensive water conservation, urban annual net water demand will increase by about 3.8 maf to 10.5 maf by 2020. Nearly half of the increased population is expected to occur in the South Coast Region, increasing that region's annual water demand by 1.5 maf.
- Irrigated agricultural acreage is expected to decline by nearly 400,000 acres, from the 1990 level of 9.2 million acres to a 2020 level of 8.8 million acres, representing a 700,000–acre reduction from the 1980 level. Reductions in projected irrigated acreage are due primarily to urban encroachment onto agricultural land and land retirement in the western San Joaquin Valley, where poor drainage conditions exist. Increases in agricultural water use efficiency, combined with reductions in agricultural acreage and shifts to growing high–value, lower–water–use crops, are expected to reduce agricultural annual net water demand by about 2 maf by 2020.
- The 1990 level and projections of environmental water needs to 2020 include water needs of managed fresh water wetlands (including increases in supplies for refuges resulting from implementation of the CVPIA), instream fishery requirements, Delta outflow, and wild and scenic rivers. Environmental water needs during drought years are considerably lower than average years reflecting principally the variability of natural flows in the North Coast wild and scenic rivers. Average annual net water demand for existing environmental needs is expected to increase by 0.8 maf by 2020. Furthermore, regulatory agencies have proposed a number of changes in instream flow needs for major rivers including the Sacramento and San Joaquin. These proposed flow requirements are not necessarily additive; however, an increase from 1 to 3 maf is presented to envelop potential environmental water needs as a result of proposed additional instream

needs and actions under way by regulatory agencies, both of which benefit fisheries.

- With California's increasing population and higher levels of affluence, water based recreation has become an integral part of satisfying urban society's desire to escape from crowded cities. State, federal, and local public water supply projects have helped provide recreation areas in addition to those already provided by natural lakes and streams. In some cases, these projects have enhanced downstream flows during times of year when natural flows are low, thus creating whitewater rafting opportunities that were not possible before reservoir operation. Often there are conflicting values and needs for the same river system. Recreation at reservoirs, natural lakes, and streams must be managed to prevent overuse and degradation.

Recommendations

The Delta is the hub of California's water supply infrastructure; key problems in the Delta must be addressed before several of the Level I options can be carried out. The framework agreement recently signed by the Governor's Water Policy Council and the Federal Ecosystem Directorate will provide an avenue for finding solutions to those problems. The agreement provides for improved coordination and communication among State and federal agencies with resource management responsibilities in the estuary. It covers the water quality standards setting process; coordinates water supply project operations with requirements of water quality standards, endangered species laws, and the CVPIA; and provides for cooperation in planning and developing long–term solutions to the problems affecting the estuary's major public values.

Also, a proactive approach to improving fishery conditions—such as better water temperature control for spawning, better screening of diversions in the river system to reduce incidental take, and better timing of reservoir releases to improve fishery habitat—must be taken so that solutions to the Delta problems mesh with basin-wide actions taken for improving fishery conditions. To that end, many of the restoration actions identified in the CVPIA for cost sharing with the State can improve conditions for aquatic species. Once a Delta solution is in place and measures for recovery of listed species have been initiated, many options requiring improved Delta export capability could become feasible.

Following are the major Level I options recommended to help meet California's water supply needs to 2020. Their potential benefits are also presented. Many of these options still require additional environmental documentation and permitting, and in some instances, alternative analyses. Before several of these programs can be implemented, identification and prioritization of environmental water needs, and funding issues must be addressed.

Demand Management

- Water conservation: By 2020, implementation of urban BMPs could reduce annual urban applied water demand by 1.3 maf , and net water demand by 0.9 maf, after accounting for reuse. Implementation of agricultural EWMPs, which increase agricultural irrigation efficiencies, could reduce agricultural applied water demands by 1.7 maf and net water demand by 0.3 maf, after accounting for reuse. In addition, lining of the All–American Canal and Coachella Canals will reduce net water demand by 68,000 af.
- Land fallowing and water bank programs during droughts: Temporary, compensated reductions of agricultural net water demands and purchases of surplus water supplies could reallocate at least 0.6 maf of drought year supply.

- Drought demand management: Voluntary rationing averaging 10 percent statewide during drought could reduce annual urban applied and net water demand by 1.0 maf in 2020.
- Land retirement: Retirement of 45,000 acres of land with poor subsurface drainage and disposal in the western San Joaquin Valley could reduce annual applied and net water demand by 100,000 af by 2020.

Supply Augmentation

- Water reclamation: Plans for an additional 1.2 maf of water recycling and ground water reclamation by 2020 could provide annual net water supplies of nearly 0.8 maf after accounting for reuse.
- Solutions to Delta water management problems: Improved water service reliability and increased protection for aquatic species in the Delta could provide 0.2 to 0.4 maf annually of net water supplies (under D–1485) and make many other water management options feasible, including water transfers.
- Conjunctive use: More efficient use of major ground water basins through programs such as the Kern Water Bank could provide 0.4 maf of drought year net water supplies (under D–1485).
- Additional storage facilities: Los Banos Grandes (SWP) could provide 0.3 maf of average and drought year net water supplies (under D–1485), and Domenigoni Valley Reservoir (MWDSC) could provide 0.3 maf of drought year net water supplies.

In the short–term, those areas of California relying on the Delta for all or a portion of their supplies face uncertain water supply reliability due to the unpredictable outcome of actions being taken to protect aquatic species and water quality. At the same time, California's water supply infrastructure is severely limited in its capacity to transfer marketed water through the Delta due to those same operating constraints. Until solutions to complex Delta problems are identified and put in place, and demand management and supply augmentation options are implemented, many Californians will experience more frequent and severe water supply shortages. Limitations of surface water deliveries will exacerbate ground water overdraft in the San Joaquin River and Tulare Lake regions because ground water is used to replace much of the shortfall in surface water supplies.

Finally, it is recommended that Level II options be evaluated, expanded to include other alternatives (such as additional long-term carryover storage in both surface reservoirs and in conjunctive operation of ground water basins), and planned for meeting the potential range of average year shortages of 2.1 to 4.1 maf and the potential range of drought year shortages of 2.9 to 4.9 maf. Level II options include demand management and supply augmentation measures such as additional conservation, land retirement, increased water recycling and desalting, and surface water development. Several mixes of State and local Level II options should be investigated and their economic feasibility ascertained to address the range of uncertainty of demand and supply illustrated in the California Water Budget.

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